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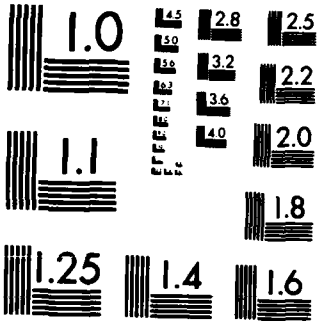

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A pulsed pump beam provides photo-thermal labelling of flowing aerosols and vapors. The labelling is detected by transient refraction or Mie scattering variations in a displaced probe beam, providing a new technique for flow and spectroscopic measurements.

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Novel Photo-Thermal Technique for Flow and Spectroscopic Measurement in a Dense Aerosol Stream

by

H. Sontag
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A. C. Tam

IBM Research Laboratory
San Jose, California

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Research Report

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Novel Photo-Thermal Technique for Flow and Spectroscopic Measurements in a Dense Aerosol Stream

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Optical techniques for investigations of aerosols are of great current interest. Photo-thermal (PT) techniques are especially attractive since they are usually zero-background and insensitive to light-scattering. For example, Campillo *et al.*[1] have measured aerosol absorption by PT modulation of Mie scattering, Arnold *et al.*[2] have determined the infrared absorption spectrum of an aerosol particle by PT shifting of structural resonances, Chang and co-workers[3] have measured evaporation rates of liquid aerosols by structural resonance effects on fluorescence, and Dasch[4] has observed laser vaporization of soot by transmission and Mie scattering. Our present PT aerosol measurements are new because: (1) We can measure properties of both vapors and aerosols in a dense fast-flowing stream (*i.e.*, resembling industrial or environmental situations). (2) We use spatially displaced pulsed beam and continuous probe beams to obtain both spectroscopic and flow information, while previous measurements used coincident beams where only spectroscopic information could be obtained.

As shown in Fig. 1 a dense mist of a liquid (*e.g.*, ethanol/water mixture) is produced and carried through a nozzle to form an free upward stream. A pulsed CO_2 laser beam (pulse duration 50 microsecond, pulse energy 10 mJ) is gently focused onto the stream by a ZnSe lens. A continuous HeNe probe beam is tightly focused onto the stream. The probe beam is parallel to the pump, and can be displaced in a vertical direction (*i.e.*, parallel or anti-parallel to the flow), the displacement z is defined as positive if the probe beam is upwards from the pump beam. The pulsed pump beam

causes a transient signal in the probe only if z is zero or positive, but there is no observable signal for negative z. Some typical signals are shown in Fig. 2. We found that vapor absorption causes a "travelling" thermal lens which can be observed by transient probe beam deflection while the aerosols can be analyzed by transient Mie scattering. Figure 2 clearly shows that the probe transient signal is systematically delayed further when z increases, demonstrating the first observation that the pulsed pump beam is providing PT labelling in the aerosol stream, and the labels can still be observed by the probe beam at distances on the order of 1 cm away. The label is PT in nature, due to the transient heating by the pump laser. By measuring the probe signal delay as a function of z, the flow speed v of the aerosol stream can be determined, as shown in Fig. 3. Also, by tuning the wavelength of the pump beam, the magnitude of the transient probe transmission signal normalized to the pump pulse energy is observed to vary as the absorption spectrum of the material. These observations show that our new all-optical transient PT probing method for flowing aerosols provides both flow and spectroscopic data *in-situ*.

This work was supported in part by the Office of Naval Research.

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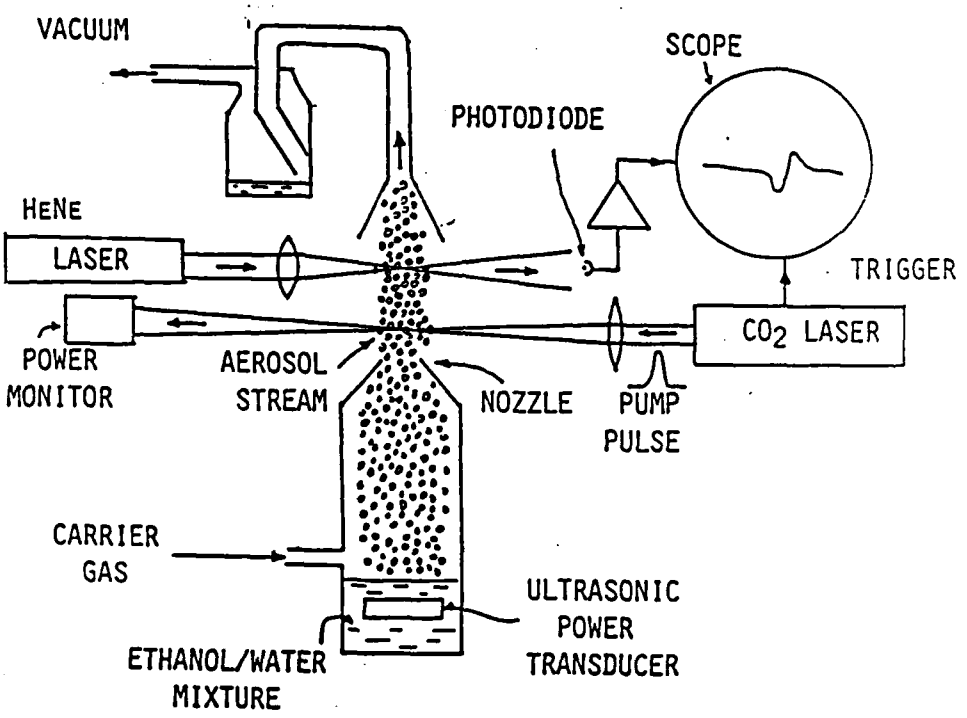
FIGURE CAPTIONS

Figure 1. Photo-thermal spectroscopy and flow measurements in a dense aerosol stream.

Figure 2. Pump pulse in (a), and transient probe signals in (b) to (d) for increasing beam separation z.

Figure 3. Graph of beam separation vs probe delay for fixed flow conditions of the aerosol stream. From this a flow speed v=8.18 m/s is derived.



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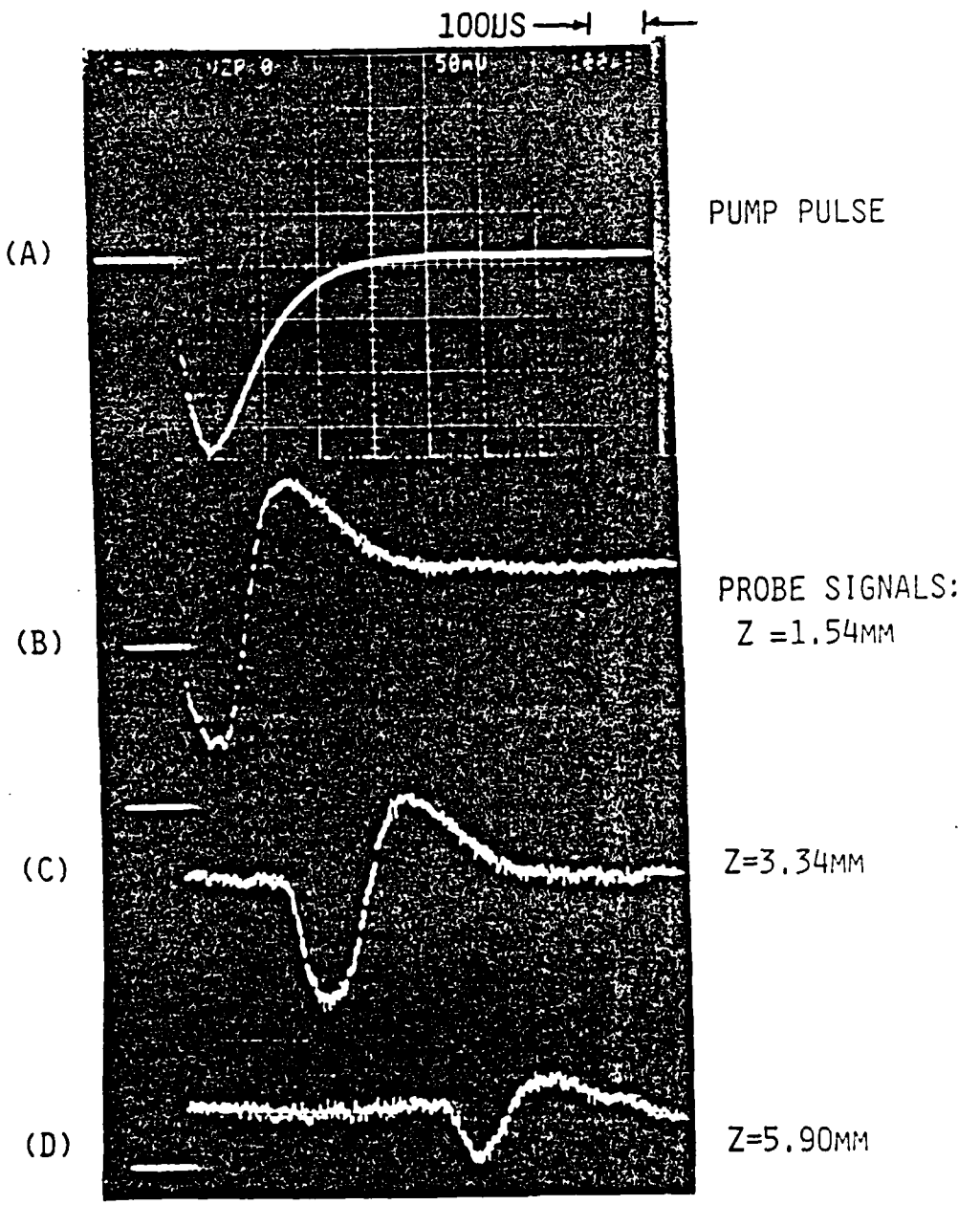

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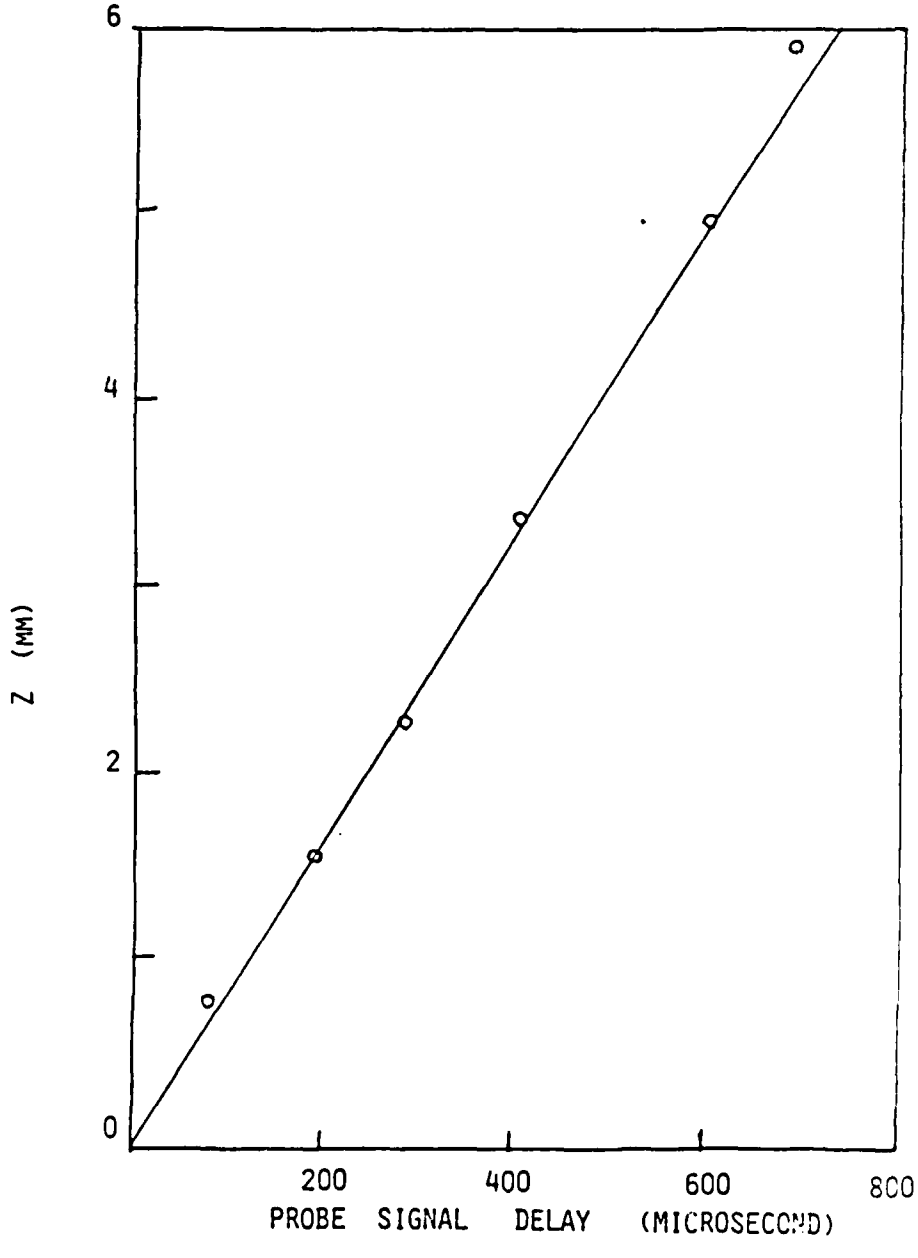

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